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Corrosion inhibition of steel in urea solution

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Urea is a cheap, yet high nitrogen bearing material among the fertilizers. Its production and use entail corrosion problems in steel structures of the plant, reinforced steel rods of roofing, flooring, etc. Studies were, therefore, carried out to assess the corrosion rate of mild steel in urea solutions by weight loss measurements. The effect of various inhibitors on the corrosion of steel in 20% urea solution was examined. Results show that a combination of inhibitors is effective in decreasing the corrosion.

Key words: Urea corrosion, inhibitors

INTRODUCTION

Urea occupies a key position amongst various nitrogenous fertilizers by virtue of its low cost and highest nitrogen content [1]. The most affected parts in the urea plants are stripper reactor, high pressure condenser, scrubber etc. In presence of water, urea undergoes hydrolysis leading to formation of carbamate ions which are highly corrosive to steel. It also reacts with cement leading to spalling of concrete in civil structures [2] which therefore warrants protective measures. So studies were carried out to assess the corrosion of steel in various concentrations of urea solution and the effect of various inhibitors in minimising the attack on steel.

EXPERIMENTAL

Mild steel specimens (2.5 × 2.5 cm) were pickled in 11% hydrochloric acid solution, finished on 120 emery and solvent degreased. The corrosion rate was determined by weight loss on immersion of steel specimens in different concentrations of urea solutions for 2 days. Later trials were made with additives in 20% solution-found to possess highest corrosivity.

RESULTS AND DISCUSSION

Table I gives the corrosion rates of steel in different urea solutions and also other properties of the solutions

It may be seen that the corrosion rate is maximum at 20 - 25% urea concentration. The pH and electrical conductivity increase with concentration while the dissolved oxygen concentration decreases beyond 20%. The corrosion behaviour of steel is similar to that in neutral salt solutions in which the rate depends upon the electrolytic conductivity and oxygen availability.

Table II shows the corrosion of steel in 20% urea solution with and without additives. Amongst the single additives studied, use of $ZnSO_4$, Na_2CO_3, $NaNO_2$, K_2CrO_4 and Na_3PO_4 give low corrosion rate (<mpy). While the surface showed rusting only in presence of $ZnSO_4$, in other cases no rusting was observed. With additives in combination,

TABLE I: Corrosion rate of mild steel in and properties of urea solutions

Sl. No	Urea conc. (%)(W/V)	pH	Electrical conductivity (μs)	Dissolved oxygen concentration (ppm) [3]	Corrosion rate (mpy)
1	10	5.9	33	7.7	4.9
2	15	6.0	43	7.7	5.0
3	20	6.2	52	7.7	6.0
4	25	6.5	61	6.3	6.0
5	30	7.3	41	6.1	5.0

TABLE II: Corrosion rate of mild steel in 20% urea solution with and without additives. Test duration: 2 days

Sl. No	Additive[α]	Corrosion rate (mpy)
1.	None	6.0**
2.	NH_4CNS	8.8**
3.	$NaNO_3$	8.4**
4.	NH_4NO_3	7.3**
5.	$(NH_4)_2SO_4$	6.3**
6.	$(NH_4)_2CO_3$	4.1**
7.	$ZnSO_4$	3.4**
8.	$NaNO_2$	2.8*
9.	Na_2CO_3	2.6*
10.	Na_3PO_4	1.6*
11.	K_2CrO_4	1.3*
12.	$Na_2CO_3 + ZnSO_4$	6.7*
13.	$K_2CrO_4 + ZnSO_4$	1.4*
14.	$NaNO_2 + ZnSO_4$	0.7*
15.	$NaNO_2 + Na_2CO_3$	0.5*

[α]System 2-11 = 0.1% additive;
System 12-15 = 1:1 mixture to make 0.1%
*Specimens show no rusting; ** specimens show rusting

the lowest corrosion rate was observed with 0.1% of 1:1 mixture of $NaNO_2/Na_2CO_3$ and $NaNO_2/ZnSO_4$. Further this value is lower than the corrosion rates with individual additives in these cases. In $NaNO_2/Na_2CO_3$ mixture the additional protection is due to the alkalinity created by Na_2CO_3 making the passive film more stable, while in $NaNO_2/ZnSO_4$ combination, it is due to the cathodic inhibition brought about by zinc ions [4, 5].

CONCLUSION

Use of $NaNO_2$-Na_2CO_3 and $NaNO_2$-$ZnSO_4$ combinations, lead to lowering of corrosion of steel in 20% urea solution.

REFERENCES

1. P N Arunachalam et al, Proc. Tutorial Symp on Corrosion Control in Fertilizer Industries (CECRI, Karaikudi), (25 July 1986)
2. T V Swaminathan, *Indian Concrete J*, **51** - 8 (1977) 234 & 253
3. *Standard methods for the examination of water and waste water* by APHA, AWWA and WPCF, Published by APHA, Washington D. C. p 440 (1975)
4. M Cohen, P Pyke and P Maurier *J Electrochem Soc*, **96** (1949) 254
5. G W Mellors, M Cohen and A D Beck, *J Electrochem Soc*, **105** (1958) 332